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In conclusion it may be mentioned that on many favourable occasions the spectroscope was carefully adjusted for C, but no trace of that line could be detected in the light of the Great Nebula. On the other hand, the continuous spectrum shows some indications of resolvability into lines or bands.

Lord Crawford's Observatory, Dun Echt:
1888, *June* 2.

Physical Observations of Saturn in 1888.

By Thomas Gwyn Elger.

In continuation of the paper presented at the June meeting last year, I submit the following observations of the planet made with an $8\frac{1}{2}$-inch silver-on-glass reflector by Calver during the months of January, February, March, and April this year, premising that, though the weather generally was not so favourable for the scrutiny of delicate detail as during the spring of 1887, on some four or five nights the atmospheric conditions were especially excellent, and on several occasions, when they were less propitious, spells of very good vision, of longer or shorter duration, were obtained. Eyepieces magnifying 284, 340, and 420 times were employed—the second being found most usually serviceable, though the highest afforded superb views of the planet on suitable nights.

Ring A.—The colour of this ring always appeared on the best observing nights to be lavender-grey, its uniformity and depth of tone, however, varying within wide limits. On some occasions it was either wholly or partially divided, about midway between the outer and inner edge, into two zones—an outer dark zone and an inner light zone, the latter being sometimes evidently the narrower. On March 5, $7^h\ 35^m$ to $9^h\ 0^m$, with superb vision, affording long steady views with powers 340 and 420, the contrast in the shading was very marked, the southern portion from the extremities of both ansæ up to the ball being very much darker than that on the northern half of the ring. On March 21, $9^h\ 15^m$ to $10^h\ 10^m$, it was clearly darker on the *p.* ansa, as was also the case on March 27, $8^h\ 15^m$ to $8^h\ 50^m$. On inferior nights a ruddy or salmon hue was frequently noted in connection with this ring—an appearance which was probably due to atmospheric causes. *Divisions.*—Though a faint, delicate, dark line, presumably Encke's division, was frequently observed last year, even on indifferent nights, not a trace of any dark division was seen this season, except on March 6, 8^h to 9^h, and on March 21. On the former date a faint dark line was glimpsed on the *s. f.* side, and on the latter, between $9^h\ 15^m$ and $10^h\ 10^m$ a similar feature was seen on the *p.* ansa, at a distance of about one-third the width of the ring from its outer edge. A narrow light streak (as was

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the case last year) was frequently observed, but on no occasion traced all round. On February 11, $9^h\ 30^m$ to $10^h\ 5^m$, it was seen on the northern side of the *p.* ansa; on February 12, $8^h\ 30^m$ to $9^h\ 10^m$, it was visible for a considerable distance, both on the north and south sides of the *p.* ansa. On March 3, $8^h\ 15^m$ to $9^h\ 15^m$, it was seen well on the *p.* ansa, and less distinctly, near the extremity of the *f.* ansa. On March 5, $7^h\ 35^m$ to $9^h\ 0^m$, it was only traceable on the north side of *p.* ansa. On the following night, 8^h to 9^h, it was once more visible on both ansæ, as on March 3—a faint dark line being noted *s. f.*, as mentioned above. On April 6, 9^h to $9^h\ 45^m$, the light strip was seen *s. p.* It was generally estimated to be rather nearer the outer than the inner edge, though on one or two occasions, notably on February 12, it seemed to be nearer the latter.

Cassini's Division.—This dark band has never impressed me as being perfectly black, or, except as regards its inner edge, well defined. On February 10, $8^h\ 45^m$ to $9^h\ 30^m$, its outer margin on both ansæ seemed "fuzzy," and without any definite limit. The same appearance was noted still more distinctly on February 12, $8^h\ 30^m$ to $9^h\ 10^m$, when ill-defined feathery projections seemed to extend from the outer edge, on E ansa, on ring A. Definition was very good, permitting these features to be steadily seen with both powers, 340 and 420, for some time. On March 5, a still more favourable night, the outer edge was recorded as very badly defined, and projections again noted *s. f.* On subsequent occasions, notably on March 6, 8^h to 9^h, and on March 27, $8^h\ 15^m$ to $8^h\ 50^m$, an evident want of sharpness and distinctness was again remarked in connection with this edge. On many nights, more especially on February 12, March 3, 6, and 21, there was a marked difference between the visibility of the Cassini division on the south and north. From the extremity of either ansa towards the south and up to the ball, it was very much darker than round the north side, where it was scarcely visible at all.

Ring B.—The gradual gradation of shade from the dark inner edge of this ring to the bright zone bordering its outer edge, which was so marked a characteristic on almost every fine night during the early months of last year, has not been on any occasion prominent. The brilliant outer zone, however, has not only given one the impression of being more bright and conspicuous, but has exhibited distinct inequalities in brightness on different segments. On February 7, 9^h to $9^h\ 30^m$, February 10, $8^h\ 45^m$ to 9^h 30, February 11, $9^h\ 30^m$ to $10^h\ 5^m$, February 12, $8^h\ 30^m$ to $9^h\ 10^m$, and March 3, $8^h\ 15^m$ to $9^h\ 15^m$, it was noted as being much more brilliant on the *f.* than on the *p.* ansa. On February 12 this difference in brightness was so remarkable that it could hardly be overlooked by anyone at all accustomed to the examination of planetary detail. On March 5, $7^h\ 35^m$ to $9^h\ 0^m$, it was noted as very brilliant on *s.f.* ansa, less conspicuously so *n.f.*

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and *s. p.*, and scarcely traceable *n. p.*, its colour, yellowish white, contrasting with every other feature of the planet. On March 21, $9^h\ 15^m$ to $10^h\ 10^m$, on the contrary, it was brightest on the *s. p.* side, and generally bright on the *p.* side, while it was only just traceable on the opposite ansa. On March 27, $8^h\ 15^m$ to $8^h\ 50^m$, it appeared to be equally brilliant all round. On April 6, 9^h to $9^h\ 45^m$, it was, once more, distinctly brighter on the *f.* side. The width of this brilliant rim was estimated on some nights as being as much as $\frac{1}{3}$, on others as little as $\frac{1}{5}$, the total width of B. No great weight, however, can be given to eye-estimations in this case, as the inner edge of the bright zone was sometimes scarcely distinguishable from the neighbouring portion of the ring The delicate rounding off of the shading from within to the outer bright zone, sometimes giving B the appearance of a solid ring, circular or elliptical in cross-section, which was so remarkable last year, was far less pronounced this season, when on some nights, definition being nearly all that could be desired, with the exception of a dusky crescent-shaped border on one or other of the ansæ, scarcely any difference in depth of tone could be noted in the region between the inner edge of B and that of the brilliant zone on the outer edge of the ring. The widest part of the crescent-shaped shading just mentioned on the inner border of B was at the extreme ends of the ansæ, and was estimated to be about $\frac{1}{4}$ the width of the ring. Its outer limit did not appear to be concentric with the ring, but curved more rapidly, so that this uniformly dusky band died out apparently on either side about midway between the major axis of the ring and the ball. When seen at all, it was generally remarked on the *f.* ansa, and only twice on the *p.* side. It was very distinct on February 10 and 12, March 3, 5, 21, and 27 (all favourable nights) on the *f.* side, and on April 6 and 8 on the *p.* side. On none of these occasions could a trace of a similar band be detected on the opposite ansa.

Ring C.—During the time that this ring was under observation last year, it was generally recorded as more or less dark in tone on both ansæ. The first satisfactory view of it obtained this season (January 29, $8^h\ 40^m$ to $9^h\ 25^m$) exhibited it as light grey in colour on the *p.* ansa, and much more distinct than it was at any time when viewed in the previous year. Its inner edge seemed perfectly regular, and its surface even in tone, except *s. p.* (near the ball), where it appeared to be somewhat darker than elsewhere. The *f.* ansa, however, presented a striking contrast in every respect. Here it was dark and scarcely traceable, and appeared to be separated from B by a narrow sharp dark line all round. On subsequent nights the following observations were recorded:—

February 1, 10^h to $10^h\ 25^m$.—On *p.* ansa light, and greyish in tone. Very obscure on *f.* ansa. Powers 340, 420.

February 3, $7^h\ 30^m$ to 8^h.—Variable definition. Light on *p.* ansa, scarcely visible on *f.* ansa. Power 284.

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February 7, 9^h to 9^h 30^m.—Variable definition with occasional steady glimpses. Light grey on *p.* ansa. Inner edge apparently regular. Width estimated as equal to half the space between inner edge of ring and ball. On *f.* ansa very obscure—difficult to make anything of it. Inner edge nowhere traceable. Powers 284, 340.

February 10, 8^h 45^m to 9^h 30^m.—Definition very good at times. Divided from B by a distinct black line, visible only on west ansa. Very obvious and light on *p.* ansa, except on south side for some distance west of the ball, where it was manifestly darker than elsewhere. On *f.* ansa it was dark and only visible in places. At times the inner edge seemed to be indented, but of this I could not be sure as it was so badly defined. Powers 280, 340.

February 11, 9^h 30^m to 10^h 5^m.—Good definition. As on the 10th in *p.* ansa. In *f.* ansa very dark and indistinct. Even at times of best seeing I could only trace the *s. f.* portion of it, the remainder being apparently as dark as the space between the ball and the ring. Powers 284, 340, 420.

February 12, 8^h 30^m to 9^h 10^m.—Good definition. Rather dark, but apparently normal in *p.* ansa. Unequally dark, patchy, in *f.* ansa. The inner edge only visible on *s. f.* side. Powers 340, 420.

March 3, 8^h 15^m to 9^h 15^m.—Good definition. Rather dark in *p.* ansa. Estimated breadth less than space between inner edge and ball. A distinct dark patch, like a notch, visible near the middle of the ansa, broadest on the face of ring, and extending nearly from the inner to outer edge. On *f.* ansa still very dark—only traceable on *s. f.* side. Powers 340, 420.

March 5, 7^h 35^m to 9^h.—Very favourable night, affording splendid glimpses of the planet of long duration. Ring divided from B on *f.* side by a well-defined black space, traceable all round ansa. A similar but broader division noted *s. p.*, being broadest where it abuts on west limb of *Saturn*. In this ansa, however, it cannot be traced on *n. p.* side. Ring somewhat lighter on *p.* than on *f.* ansa, but dark on both. On the former, the dusky spot, seen on March 3, is observed with all the eyepieces, and three or more dark areas are noted on *s.* side of *f.* ansa. Ring not traceable *n. f.* That part of the ring in front of the ball is only slightly darker than dark belt south of the equator and is lighter than any portion of ring A. The limb is visible through it, and it seems wider on the *f.* than on the *p.* side, but as the inner edge is difficult to distinguish from the faint belt behind it, this is doubtful. Powers 284, 340, 420.

March 6, 8^h to 9^h.—Definition not so good as on the 6th, though at times favourable glimpses were obtained. During a spell of good vision after 8^h 30^m I again saw the dusky spot on *p.* ansa, and three or more on south side of *f.* ansa. Powers 340, 420.

March 10, 10^h to 10^h 20^m.—Though an unfavourable night, the difference in depth of tone of the surface on both ansæ was

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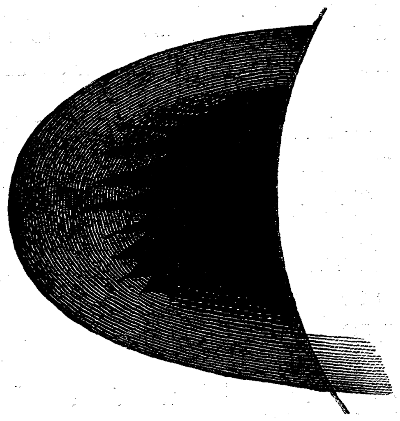
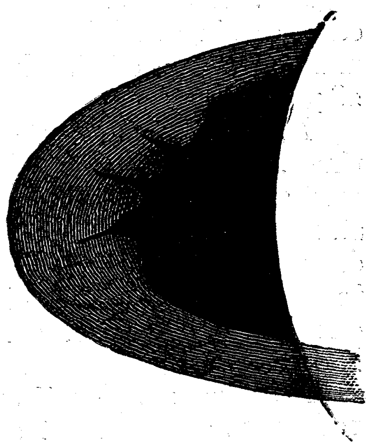
quite apparent. The ring seemed to be lighter on *p.* ansa, and broader than space between inner edge and ball. Power 340.



Ring C, March 21.



Ring C, March 27.

March 21, 9^{h} 15^{m} to 10^{h} 10^{m}.—Definition steady, vision good. Inner edge ragged and clearly indented on *p.* side, but indentations not very deep. The ring uneven in colour, though no distinct spots could be made out. On *f.* ansa it was only visible on north side. Powers 340, 420.

March 27, 8^{h} 15^{m} to 8^{h} 50^{m}.—Definition fairly good. Much lighter on *p.* than on *f.* ansa, where it is scarcely traceable, except on the north side. Inner edge on *p.* ansa scalloped, exhibiting three or four convex projections, and dark patches visible on its surface. Very light where it passes in front of ball. Powers 340, 420.

March 28, 9^{h} 30^{m} to 10^{h} 10^{m}.—Definition moderate. Light on *p.*, but obscure on *f.* ansa. Scalloped edge again noted on *p.* ansa, one projection, near the centre, being especially deep and prominent. Powers 284, 340, 420.

April 6, 9^{h} 0^{m} to 9^{h} 45^{m}.—Definition variable. Very light and distinct on *p.* ansa, though somewhat dark on the south near the ball. Scalloped edge again satisfactorily seen with all the powers. Very obscure on *f.* ansa. In front of ball it is certainly wider on *f.* than on *p.* side, as was suspected on March 5. Powers 284, 340, 420.

Belts.—A very marked change both in number, position, and visibility, especially obvious in the region between the South Polar Cap and the dark band south of the bright equatorial zone, has taken place among these delicate features since they were last observed in 1887, tending to show, if it were needed, that the fainter belts are subject to variations, similar in appearance, if not in character, to those noted in connection with the fainter cloud belts of *Jupiter*; while the wide bright equatorial band and the dark belt south of it, though apparently even more persistent than the grosser bands on this planet, would, if it were

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possible to examine them under equally favourable conditions, display the same kind of mutability as regards hue and detail. Last year the region south of the bright equatorial zone was marked by a more or less dusky zone, generally recorded as ruddy in colour, and extending to nearly $\frac{1}{3}$ of the apparent distance between the equator and the south limb, and frequently exhibiting long narrow rifts too ill-defined to represent or describe. It was bordered on the north by the darkest and broadest belt on the disc, and on the south by a band nearly as wide but less pronounced. This year this intermediate dusky zone was no longer visible as before, and though the belt which bounded it on the north was still the darkest on the planet, that on the south was only traced as an extremely faint object on the best nights, and was frequently not seen at all, even when atmospheric conditions were favourable.

The belts were usually recorded as follows, commencing from the inner edge of ring C, where it passes in front of the ball:—(1) a faint nebulous band, on some nights scarcely distinguishable from C. Frequently seen to the best advantage near the east and west limb of the planet, where, through the effect of perspective, it appears to rise above the edge of C. (2) A broad bright zone of yellowish hue, generally estimated to be the brightest feature in connection with the planet, extending to a little south of the equator. It was occasionally seen to be mottled with delicate white fleecy spots. (3) A more or less dark band (greyish blue) scarcely $\frac{1}{5}$ the width of 2. Sometimes well-defined on both edges, but far more often noted as harder and sharper on the north than on the south. (4) A greyish region, answering to the dusky ruddy zone seen last year. (5) A very faint belt, representing that which then formed the southern limit of 4, sometimes only partially visible, at other times not seen at all. (6) A uniformly grey region (on which faint belts were occasionally detected), extending to the northern edge of Polar Cap.

On several nights, when definition was favourable, the northern half of bright zone (2) seemed to be distinctly duller than that adjoining 3—notably on March 5—as if a faint broad belt existed between it and 1. Belt 3, on January 29 and February 3, was dark, and sharply defined on both edges. On February 10 it was more sharply defined on the north than on the south, and was estimated as equal in tone to the outer zone of ring A. On February 11 the southern edge was very nebulous. On February 12 both edges were badly defined. On March 21 it was very hard and sharp on the north, while the south edge was ragged. The greyish-blue South Polar Cap appeared to vary in darkness considerably on different nights. From January 17 to February 1 it was recorded as very dusky, but subsequently, from February 3 until March 5, as very light, on some nights scarcely differing in tone from the zone north of it. On the latter date it was very dark near the limb. On

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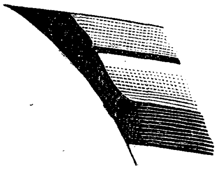
March 21 and 27, it was again described as light. On March 28, 9^h 30^m to 10^h 10^m, as being decidedly darker on the *f.* side, by the limb, than elsewhere. On April 6 it was of an even grey colour. Detail in the form of ill-defined light markings was frequently seen on band 4, which sometimes seemed to be of a warm ruddy hue. On February 10, at 9^h, a faint narrow band was observed south of 5, which seemed to be slightly inclined to it. On January 29, 5 was only traced from the east limb to about the middle of the disc. The *colour of the ball*, like that of the rings, seems to be a matter depending very much upon the quality of the night. On the best occasions, the yellowish tone of the equatorial region, the pale cinnamon hue of that extending south of the greyish-blue belt, 3, the dull grey of the region south of this, and the lighter bluish-grey or slaty tone of the Polar Cap, were manifest; while on inferior nights the cinnamon hue gave place to a ruddy colour, and the bluish tone of the duskier feature, was far less noticeable.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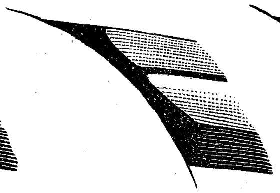
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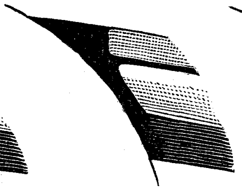
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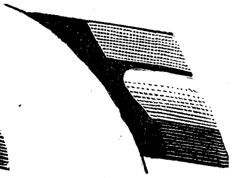
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Shadow of Ball on Rings.—Only two nights were available before opposition on which it was possible to examine the shadow of the ball. On January 9, 9^h to 9^h 30^m, power 340, it was well seen on the *p.* side, and recorded as concentric with the ball. On January 17, 8^h 20^m to 8^h 45^m, it appeared to be slightly concave on both rings, A and B. It was rather wider south than north, and did not seem so black as the sky or the space between C and the ball. No notch or projection was seen on either evening. On January 29, 8^h 40^m to 9^h 25^m (rather more than six days after opposition), and on February 3, 7^h 30^m to 8^h, the shadow (on *f.* side) was noted as slightly concave, no visible notch or projection being visible with any power. On February 7, 9^h to 9^h 30^m, it was distinctly concave on B up to Cassini's division, but convex on A (fig. 1). On February 10, 8^h 45^m to 9^h 30^m, it was slightly concave on both rings, with a slight projection at Cassini's division;—seen well with 340 and 420. On February 11, 9^h 30^m to 10^h 5^m, difficult to detect any concavity in the outline of shadow; notch just glimpsed two or three times. February 12, 8^h 30^m to 9^h 10^m, slightly concave on A and B, with a notch at Cassini's division. Shadow very black and sharp; traceable on surface of C (fig. 2).

March 3, 8^h 15^m to 9^h 15^m.—There appears to be a difference in the curvature of boundary of shadow on rings B and A, though it is concave on both. The shadow on B is part of a flatter curve than that on A, the latter widening considerably towards

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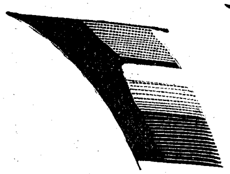
the edge of the ring. Notch at Cassini's division well seen (fig. 3).

March 5, 7^{h} 35^{m} to 9^{h}.—Very slightly concave. At times seemed (as on the 3rd) rather more concave on A. Broadest towards the south. Notch at Cassini's division acute and long, appearing to extend some distance along it (fig. 4).

March 6, 8^{h} to 9^{h}.—Concave on A and B. Width of shadow in narrowest part equal to $\frac{2}{3}$ of ring A at this place. Notch distinct with all powers.

March 21, 9^{h} 15^{m} to 10^{h} 10^{m}.—Very sharp and black, slightly concave on B, but appears to follow the curvature of the ball on A. Easily traced on C. Notch evident, but blunt (fig. 5).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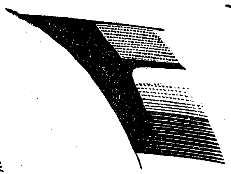
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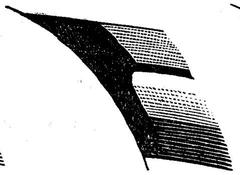
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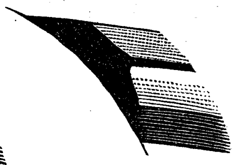
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March 27, 8^{h} 15^{m} to 8^{h} 50^{m}.—Shadow nearly concentric with ball, but rather wider towards the south. Notch blunt, but obvious (fig. 6).

March 28, 9^{h} 30^{m} to 10^{h} 10^{m}.—Shadow, ? slightly concave on B, straight on A. Notch evident (fig. 7).

April 6, 9^{h} to 9^{h} 45^{m}.—? Slightly concave on B, with a blunt protuberance at Cassini's division (fig. 8). April 8, 9^{h} to 9^{h} 30^{m}, as on the 6th.

April 11, 9^{h} 15^{m} to 9^{h} 30^{m}.—Though the night was not very favourable, good views were occasionally obtained of the shadow with powers 284 and 340. It appeared to be very distinctly concave both on B and A, the curve on both rings running up to end of notch, which was very blunt.

The objective reality of some of the features just described has, in one or two quarters, been called in question, and an endeavour made to explain them away by suggesting that they are due either to bad definition, distorting eyepieces, or defective vision. No doubt these evils, individually and in combination (especially when associated with a lively imagination), have, ere now, been answerable for the production of remarkable results; but, as regards the foregoing observations, the first two may at once be ignored; as the abnormal appearance of ring C, the peculiarities of the shadow of the ball, and other delicate details were invariably seen to greater advantage in proportion to the goodness of the night for observing purposes; indeed it was, with one or two exceptions, only on favourable nights that it was possible to see the dark areas and ragged edge of A at all. With respect to the eyepieces, they are excellent specimens of the optical skill of the late Mr. Cooke, giving good results on other celestial objects—whether double stars, *Jupiter*, or the Moon—

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hence it is inconceivable that they should go wrong on *Saturn*. Only the last objection, therefore, remains—a personal one—defective vision. This, if it has weight in this particular case, would also apply to many who are reckoned as highly-skilled observers. I may especially signalise M. Trouvelot and Dr. Terby. The former, in a valuable paper on *Saturn* (*Comptes rendus*, t. xcviii. p. 968), sums up the results of his own observations with the remark:—"*Les anneaux de cette planète, loin d'être stables, sont, au contraire, essentiellement variables et subissent des changements continuels.*" Since this was written, in 1884, much additional evidence has been forthcoming to support its truth. The existence of *masses sombres* on ring C was announced last year by Dr. Terby, and of indentations on its inner edge by myself; while equally remarkable appearances were recorded by MM. Stroobant and Stuyvaert with the 15-inch equatorial of the Brussels Observatory. This year Dr. Terby has again seen abnormal features. They have also been noted by Major Watson, who has observed dark patches on both ansæ and a serrated edge to ring C, with his fine 13-inch With mirror, at Newbridge, Ireland; by Rev. P. H. Kempthorne, M.A., of Wellington College, who has seen both spots and indentations in connection with C, with an 8½-inch With; and also by M. Gaudibert with an 8½-inch reflector, at Vaison, Vaucluse.

It is perhaps noteworthy that those, with sufficient optical means, who do *not* see them, are more or less desultory observers of the planet, while those just mentioned examined it on every available opportunity. Continuous observation, night after night, doubtless tends to educate the eye, so that it soon becomes so familiar with the object scrutinised, that delicate features, which are either only doubtfully glimpsed or not seen at all by the occasional gazer, are readily detected whenever definition permits.

No telescope of the largest type has of late, so far as I know, been brought to bear upon the rings of *Saturn*. It is to be hoped that this will be done before they become too unfavourably placed for the detection of abnormal details.

Kempston, Beds:
1888, *May* 31.

Observations of Sappho ⑳. By Professor C. H. F. Peters.

On account of the state of the weather I have not succeeded in obtaining more than the following observations. They are made with the filar micrometer of the 13-inch refractor, power 270, bright wires in dark field. The differences between star and planet have been corrected for refraction.